JUN 27 1968

MAY 29 1968

TO THE FRIENDS AND COLLEAGUES OF H. J. MULLER:

J. LEDERBERG

My husband's collection of manuscripts and correspondence, as well as the reprints of his own writings, has been deposited in the

Lilly Library for Rare Books and Manuscripts
on the campus of Indiana University, Bloomington,
Indiana 47401

It would be of historical interest if the collection were made as complete as possible. If you have any of the material listed below and would like to donate it, either in the original form or in the form of a xeroxed copy, it would be very much appreciated.

1. Handwritten letters by H. J. Muller

2. Typed letters from before 1950. (Carbons of those from 1950 on, are already in the collection.)

3. Unpublished manuscripts with joint authorship.

4. Books:

   The Mechanisms of Mendelian Heredity, Morgan, Sturtevant, Muller, Bridges. Henry Holt Co. 1915. Out of print.

   Out of the Night, Muller. Vanguard Press, 1934; Gollancz, 1936. Out of print. Hors de la Nuit, French edition. Gallimard, 1938.

   Genetics, Medicine and Man. Cornell Messenger Lectures. Cornell U. Press. Out of print. Muller, Little, Snyder.

5. Original reprints of Muller's papers missing in the collection: see separate list.

6. Anything else that you may wish to contribute, possibly more photos.

If you have material which you would like to keep now but donate later, you could let the library or me know about it.

Perhaps I should explain that in order to avoid any embarrassment, the personal correspondence will be restricted for at least several years, with few exceptions. After consultations with the various agencies concerned, it has been decided to restrict recommendations for grants for thirty-five years. Job recommendations will be handled in a similar manner, except when the person has been deceased for many years.

Since the Lilly Library is for rare material only, it is not open to the general reader, but only to the researcher, after proper identification and explanation of the type of research for which the material is needed.

1-20-69 Xerox [illegible] 1-20-72

All gifts should be addressed to:

Mrs. Hermann J. Muller
Lilly Library
Indiana University
Bloomington, Indiana 47401

I am hoping that we can still add to the interesting material on hand, and that you will feel free to write me if you have any questions.

Yours very sincerely,

Mrs. Hermann J. Muller

(See separate list for missing reprints.)

REPRINTS MISSING AT LILLY LIBRARY
(Of numbers marked with ** we have only one very brittle copy)

4. 1914. A factor for the fourth chromosome of Drosophila. Science, 39: 906.

10. 1918. Genetic variability, twin hybrids and constant hybrids, in case of balanced lethal factors. Genetics, 3: 422-499.

11. 1919. A series of allelomorphs in Drosophila with non-quantitative relationships. Read before Amer. Soc. Nat., 3: 66. 1921.

16. 1920. A quantitative study of mutation in the second chromosome of Drosophila. Read before Amer. Soc. Nat., Chicago, Dec. 31. Title in Science, 53: 97. 1921; and Rec. Amer. Soc. Nat., 3: 69. 1921.

18. 1921. A lethal gene which changes the order of the loci in the chromosome map. Read before Genet. Sec., Amer. Ass. Adv. Sci., Toronto, Dec. 1921. Title in Anat. Rec., 23: 83, (Proc. Amer. Soc. Zool.) 1922.

ADDENDA

81.
1934. Genetics as opposed to the concept of "pure races" (Russ.) Prog. Mod. Biol. vol. 3: 525-541. (Should have been listed on page 2.)

155.
1944. Failure of desemination by nitrogen; high primary non-disjunction of the insertional double-X; reddish - a new near-normal allele of white; tandem attached X's producing ring chromosomes; use of males with defective Y's to promote the laying of unfertilized eggs. D.I.S., No. 18: 56-58. (Should have been listed on page 4).

(Of numbers marked with ** we have only one very brittle copy.)

22. 1921. Micromanipulation by light waves. Read and demonstrated before Amer. Soc. Zool., Toronto.

30. 1924. A moving model of mitosis and segregation, for use in the teaching of genetics. Exhibit before Amer. Soc. Zool. Title in Anat. Rec. 29: 86.

32. MULLER, H. J., and JACOBS-MULLER, J. M. 1925. The standard errors of chromosome distances and coincidence. Genetics, 10: 509-524.

36. 1925. Life histories of identical twins, B. and J. Mimeographed notes distributed privately to geneticists.

37. 1926. Determining identity of twins. J. Hered., 17: 195-206.

**42. 1927. Artificial transmutation of the gene. Science, 66: 84-87.

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**44. 1927. Effects of X-radiation on genes and chromosomes. Read before Genet. Sec., Nashville, Dec. 1927. Awarded the annual prize of the A.A.A.S. (Abstr.) Anat. Rec., 37: 174. 1927. (More detailed Abstr.) Science, 67: 82-85. 1928.

**49. 1929. The method of evolution. Research professorship lecture read at Univ. of Texas, May, 1928. Publ. Sci. Mon., 29: 481-505. 1929. Reprinted in revised form under title: Heritable variations, their production by X-rays and their relation to evolution. Annual Rep't. Smithsonian Inst. for 1929, 345-362. 1930.

52. 1929. Variation (experimental). Encycl. Brit. 14th Ed., pp. 987-989.

**54. 1930. Radiation and genetics. Read before Amer. Soc. Nat., Jan. 1930. Publ. Amer. Nat., 64: 220-251.

62. OFFERMAN, C. A., STONE, W. S., and MULLER, H. J. 1931. Causes of inter-regional differences in crossover frequency, studied in individuals homozygous for gene arrangements. Read before Genet. Sec., New Orleans, Dec. 1931. (Abstr.) Anat. Rec., 51 (Suppl.): 109.

**66. PAINTER, T. W., and MULLER, H. J. 1932 A cytological map of the X-chromosomes of Drosophila. Proc. 6th Int. Congr. Gen., 2: 147-148. 1933.

69. 1932. Further studies on the nature and causes of gene mutations. Proc. 6th Int. Congr. Ger., 1: 213-255. 1933.

75. 1933. Report on Sixth Int. Genetics Congress. (Russ.) Prog. Mod. Biol., 2: 135-146.

MISSING REPRINTS (cont.)

79. 1934. Inversions; attached X's: rearrangement in general; deficiency; balancing of deleted X-chromosomes; triploids; extensions of third chromosome; etherizing bottles; stock lists. DIS, 2: 57-60, 62-63, 66.

80. 1934. Some fundamental lines of development of theoretical genetics and their significance from the standpoint of medicine. Read before Medico-Genet. Conf., Moscow, May 1, 1934. Publ. in Russian in Sovietskaya Clinica, 20: 17-28.

**82. 1934. The problem of the stratostat in connection with problems of interest for genetics. Publ. Acad. of Sci. USSR, p. 569-573.

91. MULLER, H. J., and GERSHENSON, S. M. 1935. Inert regions of chromosomes as the temporary products of individual genes. Proc. Nat. Acad. Sci., 21: 69-75.

92. 1935. (Genetics) Cumul. Rep. Comm. Effects Radiat. (Wash.) Nat. Res. Council, 1928-1934: 16-19.

93. 1935. Introductory chapter in book "Factors of Evolution" by J.B.S. Haldane. (Russ, trans.) Biol. Med. Pub., pp. 7-27.

**95. 1935. The position effect as evidence of the localization of the immediate products of gene activity. In Summaries of Communications of 15th Int. Physiol. Congr., Leningrad, pp. 286-289, and (1938) in Proc. 15th Int. Physiol. Congr., USSR, vol. 21, No. 5-6: 587-589.

96. 1935. Nomenclature of alleles; balancing chromosome-1 with scute ^{S1}; labeling of stock cultures; fly morgue; seeding with yeast, supplying vials with paper. DIS., 3: 48, 50, 52.

101. 1936. Construction of homozygous stocks; insertion of foreign chromosome into homozygous host stock; insertion of desired genes into attached X's; combination of invisible genes; to balance sex-linked genes; labor-saving method of starting homozygous or balanced stocks of ♂ -fertile sex-linked genes; balancing of duplications by deficiencies or lethals and vice-versa; detection of mutations; accumulation of mutations (negativing of natural selection); accumulation of mutations in given sex. DIS., 6: 7-9, 10-11, 12-13, 14-17.

102. MULLER, H. J., and BRIDGES, C. B. Balanced stocks. DIS., 6: 9-10. 1936.

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128. 1939. The mechanism of structural change in chromosomes of Drosphila. Read before 7th Int. Congr. Gen., Edinburgh, Sept. 1939. Abstr. publ. Proc. 7th Int. Congr. Gen.; J. Genet. suppl. vol, p. 221-222. 1941.

132. 1940. An analysis of the process of structural change in chromosomes of Drosophila. J. Genet., 40: 1-66.

133. 1940. New Mutants, DIS., No. 13: 52.

140. 1941. On judging the significance of a difference obtained by averaging essentially different series. Amer. Nat., 75: 264-271.

149. 1942. Locus of pale lethal; insertional translocation involved in "In (dp)", viable non-crossover, X-chromosome; stock with marked inversions of all major chromosomes. DIS., No. 16: 64-65.

**152. 1943. A stable double X-chromosome. DIS., No. 17: 61-62.

157. 1945. Genetic fundamentals. I. The work of the genes. II. The dance of the genes. Messenger Lectures at Cornell Univ., Nov, 1945. Publ. in "Genetics, Medicine and Man" by MULLER, H. J., LITTLE, C. C., and SNYDER, L. H., Cornell Univ. Press,. pp. 1-65. 1947.

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209. 1952. Sterility of Soviet Science (editor's title). United States Information Service (USIS) Feature, 3 pp., IIA-IPS CFVII-4-1152.

199. 1950. Our load of mutations. (Presidential address, read before American Society of Human Genetics, New York, December 28, 1949.) Amer. J. Human Genet., 2: 111-176. Excerpts published by Editor under title "The growing backlog of genetic defect," J. Hered., 41: 230, 240. 1951.

H. J. MULLER

What Genetic Course Will Man Steer?

"H. J. Muller's life is a symbol of twentieth century man. Born in New York City and raised in modest circumstances, Muller maintained a life-long interest in the problems of economic and social inequity. He worked at several jobs while attending Columbia University on inadequate scholarships. Through this ordeal of overwork he missed opportunities to exploit a creative mind whose gift for experimental design was recognized by his peers as early as 1910. Muller fought hard in Texas for the right to teach evolution before and after the Scopes trial. He generously supported students during the Depression and helped to edit an underground campus newspaper at the University of Texas. His belief in the 'dominance of economics over eugenics' led him to abandon the United States for a brief sojourn in Berlin where he helped found the molecular school of biology with Timofee-Ressovsky, Zimmer, and Delbruck. Hitler's ascent to power led him to the USSR where he built up a flourishing school of genetics only to find his work shattered by the rise of Lysenko in 1935 to 1937. Muller escaped possible arrest by volunteering to fight in the Spanish Civil War. After the siege of Madrid he accepted a position in Edinburgh; he later returned to London and left during the Nazi blitz for Lisbon from where he finally returned to the United States. After his Nobel Prize, awarded in 1946, Muller vigorously campaigned for radiation protection, for the freedom of science from government control, for the extension of preventive medicine to man's germinal tissue, and for a program of 'germinal choice' to offset the dilemma of 'our load of mutations.'"

—E. A. Carlson

Shortly before his death on April 5, 1967, Professor H. J. Muller gave the Bulletin *permission to publish the following article, first presented to the 1966 International Congress of Human Genetics.*

The Bulletin *is indebted to Elof Axel Carlson, associate professor of zoology at UCLA and a former student of Muller's, for the following remarks and condensation of Dr. Muller's paper.*

We—that is, humanity—will take our biological evolution into our own hands and try to steer its direction, provided that we survive our present crises. Have we not eventually utilized, for better or worse, all materials, processes, and powers that we could gain some mastery over? And are there not means already by which we can influence our heredity, and other means that we are likely to gain?

We may define genetic advances by life as the gaining of abilities for making use of the environment more effectively, and for withstanding or even making use of circumstances that earlier would have been useless or hostile. By this measure, the totality of living things has certainly advanced enormously through the ages. For it has increasingly extended life's domain, increased its resources, and made it more secure. Moreover, certain lines of descent, most notably the one leading to ourselves, have ultimately advanced the most by these criteria. They, and especially we, are the ones that can overcome the greatest difficulties, and the most adverse ones. And we, the self-styled heirs of all the ages, have constituted the very luckiest, the most improbably lucky, combinations of trials of the whole lot.

The luck that allowed any line to advance genetically was of course based on the Darwinian natural selection of mutant types, and of combinations of them. Since the kind of mutation occurring cannot be influenced by the effect it will have, and since there can be ever so

many more ways of harming than of improving any mechanism, vastly more mutations and combinations of them proved to be failures than successes in their influence on "genetic survival," "net multiplication," or simply "fitness." It is the *multiplication* of the successful mutants that plays the key role in evolution, for it alone allows additional successful steps sufficient chance to occur. To permit room and resources for this multiplication there must of course be correlative reduction in numbers, or extinction, of some less successful types, except when the new ones that succeed all go into virgin territory, or somehow make enough extra resources available for others too.

OUR FOREBEARS' RUN OF LUCK

Let us review briefly some clues to man's concatenation of luck having been so much greater than that of other organisms by focusing upon his ancestors of the last hundred million years, the primates. A long succession of events had already made the mammals the most advanced animals. Of the primates, remains of the most primitive known group, the prosimians, have been found in strata that also contain remains of dinosaurs. Prosimians must early have gained such physical advantages for active life in trees as opposable first digits, improved vision, equipment for a somewhat omnivorous diet, and uniparity. But they were soon pushed into the background and thus hampered in advancing further by their more successful offshoots, the simians: monkeys and apes. Thus, they failed to gain the simians' greater maneuverability, higher curiosity, and general intelligence.

The bodily and psychological advances made by monkeys and apes gave a further basis for the advances afterward made by the apes' protohuman offshoot, which split off from the other apes some 20 million years ago. Suffice it here to call attention to the constant view forward, with its opening up of wider opportunities, permitted by the apes' arm-mobility and consequent arm-swung mode of progression, and, derived from the latter, their semi-erect posture even on the ground.

These traits put even more of a premium than before on broad awareness, versatility, and love of variety, hence too on curiosity concerning objects, both inanimate and animate, and general intelligence. The latter includes a higher ability to transfer lessons learned in a given field to another one, and to solve problems. This in turn allowed, at least in the chimpanzee, the making of very simple tools, and some hunting of game.

Meanwhile, social intelligence, affection between companions, and cooperation had also increased; the little groups of protohumans had continued to be fairly permanent and to include individuals of all ages, and could therefore profit by emphasis on these social traits. Moreover, the division into many small social groups must have promoted natural selection for the genetic bases of social intelligence, and of social traits in general. This is because genes that tend to extend maternal and brotherly feelings to other members of the closely related little group result also in mutual aid. By thus helping the group's survival, these genes actually foster their own survival even when they lead to self-sacrifice, since others of the tiny band tend to have the same genes. By the greater growth, followed by the resplitting of the more social little groups, the genetic groundwork of cooperation was increasingly strengthened in the species.

MAN IMPROVES ON LUCK

In these ways, the genetic structure must have been laid down for a line of descent which, separating off from that of other apes some 20 million years ago, could by virtue of both its bodily and mental traits evolve to get along increasingly well on the ground. By some two

million years ago, its members had already become fully erect and much like ourselves in form, except for their little more than ape-size brain and large jaws. Since their lairs contain abundant broken bones of fair-sized game, as well as rough-hewn tools, they must not only have evolved much more initiative, including aggressiveness, than apes, but also, and most important, they must already have accumulated a substantial amount of extragenetically transmitted experience. In other words, cultural evolution, a process so nearly unique in the human line, had begun in earnest.

Like the evolution of the genetic constitution, that of culture requires the arising, the transmitting, and the selection of innovations. But since the cultural innovations are in thought and behavior, their transmission is by some form of imitation, not heredity, even though genes must afford the abilities for these processes. Of course this form of transmission allows a much more rapid spreading than that through differential multiplication.

During these developments human foresight as well as hindsight became enhanced. Hence the initiation of cultural innovations gradually, and with the scientific technological breakthrough very rapidly, became less haphazard, unlike that of mutations. They could increasingly be preselected to advantage, more reliably and rapidly post-tested, and their transmission became faster and wider. Larger steps then became more feasible, and even necessary.

It is generally conceded that the advances of science and technology already carry the physical potential of bringing dignity, affluence, health, enlightenment, and brotherhood within the reach of all. It is also conceded that, because of the dearth of really integrative and cooperative thinking, and the inertia of old ways, these very advances are misused to cause the desperate crises of fast mounting population, massive depletion of resources, mass pollution, maldistribution, mass want that knows it need not exist, inflexible privilege, mass miseducation along outgrown lines, mass deception, frenzied fanaticism, mass coercion, the threat or actuality of mass slaughter, and that of the destruction of civilization.

Thus, the changes in social conditions constitute, so far, no more than a now-foreseeable larger cultural step forward which has become mandatory for the survival of civilization. It can bring no utopia—there will never be such a status, it is to be hoped—but it will be, in a sense, only a beginning of progress on a somewhat less insecure basis.

MAN UNDERMINES HIMSELF

Just as natural mutations had to be stringently sifted by natural selection if a population were to advance or even not to deteriorate, so, in species divided into many small groups, the mutational combinations in each had to be sifted, by a longer-range natural selection, in the interests of the species as a whole. And again, genera with only one species had, other things being equal, less chance of surviving than did multi-specific ones, since any single species is so likely to prove, in the still longer run, to have been a natural error. This is shown by the fact that such a tiny per cent of species of the past have turned out to represent lines that persisted. In accord with this principle is the finding that the category with the highest per cent of survivals has been that of phyla, and that successively narrower categories have had a correspondingly decreasing survival rate.

In the case of man, it has been intrinsically dangerous for him to have so long existed as just one species. He has been saved not only by his unparalleled advantages but also by having until recently been divided into thousands of tiny bands, of at most a few score members each. In fact, as we have seen, this condition was especially favorable for the genetic enhancement of cooperative traits, including, I might add, those promoting group initiative or even—to use a harsher word—aggression. Until some two hundred generations ago the population pattern remained like this over by far the largest portion of the area inhabited by man. However, the agricultural revolution resulted in larger, denser, fewer groups, and the urban revolution greatly intensified this trend, thus practically preventing further genetic advances based on intergroup competition and even, in all probability, threatening the maintenance of those previously gained.

At the same time, intragroup natural selection, working via families and individuals, is also counteracted as much as our improving techniques can do so, by saving everyone whom they can for survival and for reproduction. They have already become highly effective in this job. This means that mutations having a net detrimental effect on body or mind may now be accumulating almost as fast as they arise. We can escape the inference that such mutations far outweigh any advantageous ones only by believing that mutations are designated by Providence for a species' direct benefit, but in that case we run contrary to the clear experimental results.

These considerations show that modern culture is used to achieve maximal saving of lives and fertility, unaccompanied by a conscious planning which would take the genetic effects of this policy into account. Our culture thus protects against elimination of mutations detrimental to bodily vigor, intelligence, or social predispositions. Hence it must allow more accumulation of detrimentals in populations than would otherwise be the case. It appears wishful thinking to suppose that there is in our type of culture a built-in selective mechanism, not designed by us intentionally, which acts over a long period so as adequately to replace the earlier positive feedback whereby the genetic constitution was advanced.

Yet degeneration by passive accumulation of mutant genes is extremely gradual in manifesting its effects. The

reason for this creeping pace is that most mutant genes exert such minute effects, at least when the given gene has been received from only one parent. The problem of creeping genetic deterioration is not acute in comparison with the fast-growing menaces presented by our cultural imbalances.

The presently much more important genetic problem arising out of modern cultural conditions lies in the need for a further advance in the genetic level of those psychological endowments which have already attained a height so distinctive of man. These are cooperativeness and general intelligence, including the creativity which arises from high initiative working through high intelligence.

ADJUSTING TO NEW CONDITIONS

A stronger, more broadly acting cooperativeness is becoming imperative for adjusting to the relatively new conditions of life in large communities, and especially in the hoped-for world community of equal opportunities. Even in the scant two to four hundred generations since the ancestors of most people gave up living in tiny bands, there may have been some significant passive accumulation of retrograde genetic changes that adversely affected one's brotherly feelings toward more distant associates. So-called enlightened self-interest is no substitute. It can lead people in communities already having socially oriented practices to conform to these though it alone would not initiate such communities. But these same conformists may, on feeling safe from exposure, engage in unfair, cut-throat competition, covert fraud, or more extreme criminality.

More modern means of bringing up the young and of otherwise influencing the mind will doubtless be much more effective than today in the development of social feelings and behavior, and the shrinkage or repression of antagonistic ones. Yet we are far from knowing to what extent practicable treatments of these kinds would be able to rival or exceed a deep and broad warmheartedness which was genetically built in. Meanwhile, the exigencies of recent culture call on us not to leave a stone unturned that could cause more of the population to be of this predisposition.

The avoidance of disaster would be far from man's only motivation in seeking a stronger, broader, brotherly love. Many of us realize the truth behind the saying "Love is what makes the world go 'round." Since such feelings and behavior have already been built into our genetic constitutions and built up in our cultures to a considerable although not now sufficient degree, we do appreciate and crave them, even for their own sakes. We have in this way been led into a situation where more brotherly love will at the same time promote our survival, help to remove the aimlessness and sense of alienation so prevalent today, and afford people deeper inner fulfillment in working for their now vast community.

As for intelligence, consider how lost most people are today if they try to grapple realistically with our bewildering ideological, social, technical, or scientific problems. In all these areas more background, penetration, and integrative ability than they have are fast becoming required. Personally, if I had an opportunity to gain greater intelligence or understanding I would have any and all means of doing so used, except where, like Faust, I had to "sell away my soul" to achieve it. Moreover, our species as a whole for a very long time made the same choice, even though unconsciously. Hence our own dominance.

In fact, in consequence of the long-continued genetic selection in that direction, intelligence and probably cooperativeness are traits which would allow artificial selection of their positive extremes without, or with minimal, upsets in other respects. This conclusion is verified by the relatively high level of vigor and of other valuable attributes which these extremes display, and by the positive correlations among nearly all these traits.

There seems no reason why there need be any limit, except that set by our intelligence, to the advances made in our science and technology, and to the creative powers they would allow us to exert. Nor do we now see any necessary limit to intelligence, although great increases in human intelligence would doubtless require, at times, breakthroughs released by anatomical or biochemical innovations in the brain or accessories of it. Such innovations—for example, the *corpus callosum*—have arisen in past mammalian genetic evolution. In culture, there have been analogous ones, such as writing.

WORKING TOWARD THE MAJOR AIMS

The most basic way of working toward the major aims is to educate everyone not later than in high school in the main principles of biology, including especially genetic and cultural evolution and their lessons for ourselves. On the heels of this should be a sketch of world history, depicting the growing unity of man.

However, with the educational background outlined, increasingly large numbers of couples who were suffering from sterility in the husband would be eager to avail themselves of means of having one or more children derived on the male side from someone they both held in deepest regard as a person physically by no means inferior while morally and mentally really outstanding. There are perhaps ten thousand children a year produced in this country by artificial insemination with semen from donors chosen by the physician; but he does not select them according to such standards and he keeps their identity secret from everyone, including the couple. Well-endowed children would be far more desired if the couples were allowed to exercise the deciding voice in the choice of the genetic father after seeing the records concerning a wide range of possible ones, considering counsel concerning them, and judging which of them have shown more of the traits preferred by the

couple themselves. Are not fertile couples nowadays expected to make their own choices of their partners in marriage, and are they not in that way allowed to choose also—even though with far less directness or likelihood of getting what they prefer than by the method here proposed—the kind of children whom they themselves want?

Openness of choice regarding donors would make it desirable that the semen had usually been stored, preferably for decades, after the donors' decease. Thus the disclosure of the fact that a given person had been the donor could no longer handicap him nor open the possibility of leading to personal entanglements between him and the recipient couple. Moreover, perspective could better be gained on the possible donors' phenotypically expressed merits and their genetic reliability in passing these along—information which would be invaluable in the making of choices.

Gradually, increasing numbers of non-sterile couples also would want to take advantage of so attractive an opportunity, for at least one child in their family. The first participants would be those wanting the child spared some defect of the husband's, and other idealistic realists, who were far from subnormal. For all of them, clearly, quite open choices, made voluntarily, but after counseling and considering of the documentary evidence, would be essential. Then later, others would be proud to follow suit, letting it be known that they had done so.

There are many reasons against using secrecy in this "germinal choice." One is that adopted children usually find out that they have been adopted, as would "half-adopted" ones. The adopted child's attempt to discover his genetic derivation when (as is now usual) it is a closely guarded secret, commonly acts like a cancer in his life. On the other hand, knowledge of the facts would exert the opposite influence. Moreover, due appraisal of the data actually *requires* genetic recording of an open type. So does the making of genetic judgments about the future possibilities of an individual's germ cells, as well as the avoidance of incest, when the time comes for any given child to reproduce.

Of course the couples would be warned beforehand that genetic segregation and environmental influences allow the results of no human reproduction to be predicted, and that such selection as here depicted only *weights* the results in their favor. It would, however, be pointed out that outstandingly good performance has almost always required a combination of both favorable environment and favorable heredity, and that in heredity the child stands on the average half-way between the means of its two genetic parents.

Then as the results, so favorable on the whole, of the relatively few first trials gradually became known, ever more couples would want to follow these pioneers' example; that is how new customs usually start. Previous taboos against the practice would dwindle. In their place, a new atmosphere of hope would emerge: hope both for the rewarding results likely to accrue to the couples themselves, and hope among them and others for mankind in general. Thus a genetic leaven would tend to diffuse through the population, and also a cultural, spiritual leaven. At last *human* resources, even on the genetic side, would begin to be enhanced at an accelerating pace.

Despite the differences in choice among couples, they would wish, and should be guided, to include some of the more special gifts or predilections which tend to support or channel the two major ones of cooperative disposition and general intelligence aimed at by all. Among these are joy of life; strong feelings combined with good emotional self-control and balance; the humility to be corrected and self-corrected without rancor; empathy; thrill at beholding and at serving in a greater cause than one's self-interest; fortitude; patience; resilience; perceptivity; sensitivities and gifts of musical or other artistic types; expressivity; curiosity; love of problem-solving; and diverse special intellectual activities and drives. This list is very incomplete, the traits are complex, and many overlap and are interdependent. Physical traits also—for example, longevity, late senility, vigor, good automatic regulation, agility—should be given considerable place. No one has nearly all these mental and physical endowments, but that choice should be made which, while largely consistent with the counsel, best fits that couple's ideals.

As these more special gifts become commoner in the population they can and should be more and more combined. This process will not ultimately reduce diversity, for the resulting population of more generally well-endowed individuals will of course branch out again diversely from the higher general level so attained. Thus it will gain still greater aptitudes, of varied kinds in its different members.

In getting this project started, it is of the utmost importance that rigorous precautions be taken to insure that the persons in the group or groups undertaking it genuinely understand and favor the two major aims previously stressed. Persons who favor what *they* consider genetic improvement are of course all agreed on the major value of intelligence. However, they are far from agreed on the need for more cooperativeness, and even of those who believe they favor it a large number are gravely mistaken about its nature. That is one reason it has here been placed first, before intelligence. Many persons would today consider as desirable cooperation joint actions that would give preference to their own race, or nation, or class, or institution, or religious or provincial group, rather than to mankind as a whole. I do not mean by this to imply that mankind as a whole might never be served by one's taking sides in a dispute —far from it—but that a consistent policy of favoring one's own side just because it is one's own is contrary to the kind of cooperation needed in today's world.

Thus the group of prime-movers, to start with, must be small and carefully chosen, and guided by rules that maximally safeguard their future observance of this interpretation of social values. They should of course have as participants not only persons specialized in genetics, in the physiology of reproduction in its theoretical and medical aspects, in psychology, and in social sciences, but also representatives from the field of values and from other truly humanistic fields. In this connection, it is important to note that I have found not a few religious or ideological leaders of diverse kinds, to adopt a not unfavorable attitude toward this project when it was explained. Included were representatives of the Catholic, Methodist, and Unitarian-Universalist denominations, of Judaism, official Humanism and Freethinking. Moreover, persons brought up to Buddhism and to Shintoism have expressed approval.

As regards the attitude of the above groups toward intelligence, they should keep in mind that eminence and creative intelligence are far from the same thing, though usually confused. Truly creative intelligence is likely to break barriers that were previously observed. Therefore these creative, highly intelligent persons all too often fail to be recognized as such by their contemporaries, although they have a relatively better chance of being so recognized by the following or a still later generation. That is another reason for storing most of the semen for decades. One of the best ways for getting recognition of the fact that our own aims are not narrow or biased is to have included in the material stored that from varied races and social groups, and to raise no objection to any couple of a different race or group using such material if they want to; but they should never be pressured in either direction on this point. Of course the data seen regarding the donors will include information about their race, social class, etc., for these matters often have much bearing on the environments they had to contend with, or benefited from, and therefore on the amount of contribution from genetic sources.

The taking of extra precautions to insure a sound, forward-looking social attitude on the part of the prime movers and supporters of the project of germinal choice is made especially important by the present mores of our American society. Although it is far advanced in social outlook and practices as compared with its condition of only half a century ago—as my personal recollections can vividly attest—it has not yet advanced far enough along this road to make "performance," as measured by mundane success in our present society, a reliable clue to the possession of the two major traits here stressed.

Although the chief seeds of Western progress do lie in its science, technology, education, and struggling democracy, its most conspicuous spirit is after all that of raucous, hypocritical and often misleading salesmanship, aided by vulgar display, along with mass distractions, petty politics, and a growing militarism.

In view of this situation, still so confused and subject to strong and dangerous currents and countercurrents, unusual vigilance will be indispensable for keeping the aims of the genetic betterment group here proposed from becoming perverted.

TECHNIQUES, RESEARCH, AND PRACTICAL AIDS

As is now so well known, human spermatozoa can be kept deep-frozen at the temperature of liquid nitrogen (and lower), without deterioration during prolonged storage, even though the processes of freezing and thawing still incapacitate for fertilization a minority of them. The addition of glycerin, and probably still better dimethyl sulfoxide (DMSO), considerably reduces this undesired effect. At several places in this country, and in at least one abroad, banks of frozen sperm are already being kept. The infants from the deep-frozen sperm have been comparable in their normality with those from unfrozen (or unmanipulated) sperm. However, there has been no attempt so far as is known to procure for any of these banks the semen of donors who are outstanding.

Research is badly needed concerning ways of "stretching" the amount of use possible for a given sample, since suitable dilutants, long known for domestic animals, have not yet been found for man. Nor have ways yet been found of reliably fertilizing a human egg by a sperm *in vitro*, since some kind of sperm "capacitation" is needed before hand, which normally occurs in the Fallopian tubes. Another need is to find out how immature germ cells, that could of course be kept deep-frozen like other tissues, can be caused to develop into normal spermatozoa *in vitro*; this would make possible the unlimited use of a given sample of immature germ cells.

With changing mores regarding germinal choice these services would eventually open much more possibility of choice to recipient couples, and with more choice the mores would change more rapidly, in a self-accelerating cycle. Thus the preliminary choosing of donors would become largely unnecessary. All the more necessary, however, would be the adoption of means of insuring that the counselors, and those engaged in choosing germinal material for their families, recognized and truly understood the major aims here stressed.

PROSPECTS

If to some people such discussions seem "far out," it should be remembered that they deal with measures closer to realization than those of applied gene knowledge of the traditional kind, and ever so much closer than those of "genetic surgery." In fact the latter procedures also would have the same weighty problem of aims to decide if they were not to be confined to matters which, by comparison, were trivialities. As we have seen, the germinal choice by empirical methods that is so much closer to realization still has to clear one or

more technological hurdles of importance before it can be of very wide use. But these should prove readily negotiable if subjected to some concerted action.

In the empirical germinal choice project it is the matter of values that looms as by far the most important one at present. This is especially the case because so many people who would like to be associated with it fail to realize its importance, or what the major values should be, and are therefore striving to get the techniques going, willy-nilly.

We as geneticists concerned with man should see it as a part of our own responsibility not only to enlighten the public but also to promote, in the meantime, the collection, documentation, and storage of exemplary germinal material. This would be that of men who best represent the major aims of enhanced cooperativeness, based on more heartfelt, broader brotherly love and of more creative and generalized intelligence. Only in that way can we meet the obligation we all have to the multitudes to use the insights they afforded us in behalf of their and our successors.

We must avoid getting sidetracked into acceptance of the delaying procedure so prevalent in both academic and political circles, which declares: "This needs more study!" Of course it does, but it is clear that there are certain things which can and must be done at this point; also that some of us are the ones to do them, in collaboration with suitable persons in other fields, whom we must find and encourage. Chief among these immediate tasks is the starting of the practice of accumulating germinal stores and records, derived from persons who so far as we can see embody the major traits here stressed. The example thus set by us is the main present feature of this starting effort.

On the whole, physicians, especially those concerned with reproduction and the urinogenital organs, who would be willing to give up dictatorship and secrecy as principles to be adhered to in inseminations carried out under the germinal choice project, would be important to have as participants in it. But they are extremely hard to find. Meanwhile the work of getting the project going must be undertaken as soon as possible, and both medical and legal aid will eventually be forthcoming.

Thus we should not let ourselves be discouraged by the temporary difficulties. We should not only bear in mind the urgent need for success. We should also recall that, after all, man has gone from height to height, and that he is now in a position, if only he *will*, to transcend himself intentionally and thereby proceed to elevations yet unimagined. He no longer can do so unintentionally. It is up to us to do our bit in this purposive process, and to use what we know constructively, rather than remain in that ivory tower which has the writing on its wall. Our reward will be that of helping man to gain the highest freedom possible: the finding of endless worlds both outside and inside himself, and the privilege of engaging in endless creation.

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